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Kumbu yams: Nutrition dense, underutilised staples for equitable, climate smart food systems and rural livelihoods

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Abstract

Growing food and nutrition insecurity in Africa is closely linked to narrow, cereal dominated systems that marginalise indigenous staples and constrain health oriented diversification. Kumbu yams (Nyake, Mwende, Jaseh), a wild Dioscorea complex from the Mount Cameroon Region, are positioned here against the reference staple D. rotundata to evaluate their potential as next generation "super staples" for climate smart, nutrition sensitive food systems. Semi structured questionnaires administered to 583 respondents across 41 villages ($\alpha = 0.05$) showed that Kumbu is either a "wild yam in process of domestication" or "in process of extinction": only 38.4 % of households still cultivate it, 69.3 % report severe seed scarcity, 30.7 % prefer other yams, and 68.1 % cannot distinguish cultivars, indicating rapid erosion of indigenous knowledge and genetic resources. Building on this diagnostic, morphological and molecular characterisation resolved Nyake, Mwende and Jaseh as three distinct candidate Dioscorea species, >99 % similar at genus level and closely allied to wild African yams (D. praehensilis/D. abyssinica), suggesting shared evolutionary origins and high likelihood of new species to science. Agronomic trials established sett propagation, combined with beneficial microbes and poultry manure, as a practical low input package, raising yields up to 37,075 ± 2,392 kg ha^{-1} versus 9,569 ± 549 kg ha^{-1} under minisett, while simultaneously reducing tannins and phytates by up to 84 % and increasing ascorbic acid. Comparative nutritional profiling demonstrates that all three Kumbu cultivars deliver more than double the metabolisable energy of D. rotundata on a dry weight basis, with substantially higher protein, useful fat, ash (mineral proxy) and exceptionally elevated vitamin C (1,716–2,412 mg 100 g^{-1}), other vitamins alongside safe dietary levels of tannins, phytates and oxalates. Thus, while D. rotundata remains a conservative bulk energy staple, Kumbu clearly emerges as a high value, nutrient dense, health promoting yam complex ideally suited for nutrition sensitive agriculture, value added product development and equitable rural income generation. We argue that strategic valorisation of Kumbu—through seed system support, on farm conservation, breeding to fine tune oxalate/alkaloid profiles and integration into extension programmes—could reposition this wild yam as "Africa's next super staple" within tropical food system.

Keywords: Indigenous staples, kumbu yam, nutrition sensitive food systems, rural livelihood, underutilised crops

Introduction

Yam (genus *Dioscorea* L.) comprises some 600–644 species, of which only a handful — *D. rotundata*, *D. alata*, *D. cayenensis*, *D. esculenta*, *D. bulbifera* and *D. dumetorum* — are widely cultivated for food (Andres et al., 2017; Bhattacharjee et al., 2011). Yam ranks fourth among tuber-root crops globally and third in Cameroon after cassava and taro, yet national output remains constrained by low productivity and a narrow cultivar base (Padhan & Panda, 2020; Azeteh et al., 2019). Food and nutrition insecurity affects roughly 16 % of Cameroonians (Mugiya & Hofisi, 2017), a situation aggravated by dependence on a narrow range of cereal staples that marginalises nutrient-dense, underutilised indigenous crops.

In the Mount Cameroon Area, farming communities cultivate a semi-domesticated, wild *Dioscorea* complex known locally as "Kumbu" (folk cultivars Nyake, Mwende and Jaseh), embedded in Bakweri and Bomboko indigenous knowledge systems yet taxonomically unresolved, agronomically undocumented and nutritionally unquantified, leaving it exposed to genetic erosion (Laird et al., 2011; Yasuoka, 2013). This paper reports research addressing four objectives: (i) document indigenous knowledge and use of Kumbu; (ii) characterise its cultivars morphologically and molecularly; (iii) evaluate their agronomic response to propagation technique and nutrient source; and (iv) profile their nutritional quality relative to the reference staple *D. rotundata*. The work supports Sustainable Development Goals 1, 2 and 12, informing seed-system, conservation and dietary-diversification policy for underutilised indigenous staples.

Material and Methods

Study area. The study was conducted in the Mount Cameroon Area (Fako and Meme Divisions, South West Region, Cameroon; 4.055–4.378° N, 9.031–9.294° E), comprising 41 villages on fertile volcanic soils under a monomodal rainfall regime of 2,000–10,000 mm yr^{-1} (Tening et al., 2013). Field trials were sited at Bova (4°10′55″N, 9°15′39″E, ~1,000 m a.s.l.) on well-drained, moderately acidic clay-loam soils.

Ethnobotanical survey. Following Slovin's (1960) formula (N = 1,479 registered yam farmers, MINADER 2023; e = 0.05), a minimum sample of 315 was computed; 583 farmers across all 41 villages were ultimately interviewed using pre-tested, semi-structured questionnaires, complemented by eight saturation-based focus group discussions for triangulation. Data were analysed in SPSS v.21 using descriptive statistics, Pearson's chi-square, Cramér's V and Cohen's kappa ($\alpha = 0.05$).

Morphological and molecular characterisation. Three farmer-recognised cultivars (Jaseh, Mwende, Nyake) were established in a randomised complete block design at Bova and scored against IPGRI (1999) yam descriptors; correspondence and cluster analyses were performed in MINITAB 17. Genomic DNA was extracted (Zymo Quick-DNA Plant/Seed Kit), and the chloroplast *matK* barcode region amplified by PCR, Sanger-sequenced (Inqaba Biotech), and compared with GenBank accessions by BLAST. Sequences were aligned in Clustal Omega, and a maximum-likelihood tree (GTR+G+I model, 1,000 bootstrap replicates, MEGA X), a NeighborNet split network (SplitsTree4) and a median-joining haplotype network (PopART) were constructed against 20 reference *Dioscorea* taxa.

Propagation and nutrient-source trial. A 3 × 4 factorial (cultivar × nutrient source: inorganic fertiliser, beneficial-microbe inoculant, poultry manure, untreated control), replicated four times, and a complementary 3 × 3 factorial (cultivar × propagation technique: sett, minisett, milking/double-harvest) were established over the 2023–2024 seasons following Aighewi et al. (2020) protocols. Tuber weight, length and diameter were recorded at harvest and yield (kg ha^{-1}) computed; data were subjected to GLM ANOVA with Tukey HSD ($\alpha = 0.05$, MINITAB 17), and a discounted cash-flow cost–benefit analysis compared treatments.

Nutritional and phytochemical profiling. Sun-dried, milled tuber flour (triplicate per cultivar) was analysed by SGS South Africa (Pty) Ltd for proximate composition (AOAC methods), anti-nutritional factors (tannins, phytates, oxalates), phytochemicals (saponins, flavonoids, total phenolics, alkaloids) and vitamins A, C, E and B9, with antioxidant capacity expressed as Trolox equivalents. Results were benchmarked against literature values for *D. rotundata* (Alinnor & Akalezi, 2010) and analysed by ANOVA with Tukey pairwise comparison ($\alpha = 0.05$).

Results and Discussion

Indigenous knowledge is eroding faster than domestication is advancing. Of 583 respondents, only 38.4 % (223 farmers) still cultivate Kumbu; among non-cultivators, 69.3 % cited severe seed/planting-material scarcity and 30.7 % preferred other yams. Even among growers, 89.6 % maintained fewer than five stands, confirming subsistence-scale, non-commercial use (94.3 % of output was never sold). Cultivar knowledge is itself narrowing: 68.1 % of respondents could not distinguish Kumbu cultivars and 92.6 % knew no alternative local names, although ten vernacular names collapsed into thirteen farmer-recognised "cultivars," of which Nyake and Mwende were most preferred (18.0 % and 8.6 % of citations respectively), overwhelmingly for good taste ($\chi^2 = 36.97$, $p = 0.017$, Cramér's V = 0.235). These patterns justify our characterisation of Kumbu as a "wild yam in the process of domestication" — or, on current trends, "in the process of extinction" — a duality also documented for other African wild-yam complexes exploited opportunistically by forest-dependent communities (Yasuoka, 2013; Laird et al., 2011).

Morphological and molecular data resolve three distinct candidate species. Cultivars did not differ in leaf shape or colour, but diverged significantly in tuber morphology (Figure 1) and in vine girth (Nyake 5.46 ± 0.09 mm vs Mwende 5.04 ± 0.01 mm), spine density (Jaseh 2.78 ± 0.01 vs Nyake 1.97 ± 0.09 spines) and leaf number (Nyake 89.2 ± 7.4 vs Jaseh 55.2 ± 4.9; $p = 0.000$ for all). Cluster analysis placed Nyake at 0 % similarity to the other two, and Jaseh–Mwende at 71.97 % similarity, both well below the 95 % conspecificity threshold, confirming three taxonomically distinct entities rather than mere folk labels. BLAST analysis of the chloroplast *matK* barcode confirmed genus-level identity (99.49–99.66 % certainty, 100 % query coverage) but could not resolve species identity, a limitation attributable to the sparse representation of African *Dioscorea* in public sequence databases (Noda et al., 2020; Zhao et al., 2018). The maximum-likelihood tree (Figure 2) placed the Kumbu clade closest to the wild West/Central African species *D. praehensilis* and *D. abyssinica* (bootstrap 100/73 %), distinct from the *D. rotundata/D. alata* cultivated clade, while the NeighborNet network showed reticulate signal consistent with historical hybridisation, and the haplotype network placed Kumbu one to two mutational steps from *D. praehensilis*, suggesting shared ancestry and possible human-mediated dispersal. As new *Dioscorea* species continue to be described from similarly under-sampled regions (e.g. *D. hurteri*, Hills et al., 2018), we consider it plausible that Nyake, Mwende and Jaseh represent species new to science, pending full taxonomic description.

Figure 1: Tubers of the three Kumbu cultivars — Mwende (left), Nyake (centre) and Jaseh (right) — illustrating the pronounced divergence in tuber shape, size and skin texture that underlies their morphological distinction.

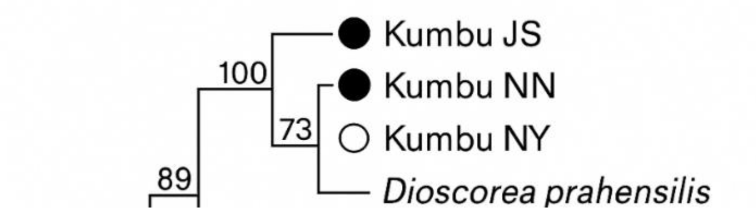

Figure 2: Kumbu clade from the maximum-likelihood phylogenetic tree (matK, GTR+G+I, 1,000 bootstrap replicates) showing the three cultivars — Jaseh (JS), Mwende (NN) and Nyake (NY) — forming a well-supported monophyletic group (bootstrap 100/73 %) sister to the wild West African species D. prahensilis, molecularly distinguishing Kumbu from cultivated Dioscorea taxa.

Sett propagation with poultry manure and beneficial microbes is the best-performing low-input package. Propagation technique had a decisive effect on tuber size and yield (Table 1): sett-propagated plants produced the largest tubers (21.76 ± 1.74 cm diameter; 3.71 ± 0.24 kg) and highest yield (37,075 ± 2,392 kg ha^{-1}), roughly fourfold that of minisett (9,569 ± 549 kg ha^{-1}), with milking intermediate ($p = 0.000$) — consistent with the physiological expectation that larger propagules carry greater carbohydrate reserves, sprout faster and build larger leaf area before canopy closure (Danquah et al., 2018, 2022). Cost–benefit analysis confirmed sett as the most profitable option (gross profit 19,555,800 FCFA ha^{-1} vs 18,427,500 FCFA ha^{-1} for minisett); minisett is therefore best reserved for rapid multiplication of scarce planting material rather than ware production. Among nutrient sources, poultry manure reduced tannins and phytates by up to 84 % relative to inorganic fertiliser and increased ascorbic acid, while inorganic fertiliser raised tannin levels most (7.88 ± 1.45 mg 100 g^{-1} vs 1.29 ± 0.19 mg 100 g^{-1} under microbial inoculation) — evidence that organic and biological amendments simultaneously raise yield and food-safety quality.

Table 1: Effect of propagation technique on Kumbu tuber size and yield (mean ± SE, pooled across cultivars, 2023–2024 seasons).

Propagation technique	Tuber diameter (cm)	Tuber weight (kg)	Yield (kg ha^{-1})
Sett	21.76 ± 1.74	3.71 ± 0.24	37,075 ± 2,392
Milking (double harvest)	15.82 ± 0.91	1.94 ± 0.11	24,771–28,729
Minisett	10.99 ± 0.48	0.96 ± 0.05	9,569 ± 549

Kumbu is a nutritionally superior alternative to the reference staple. Proximate analysis showed Nyake with the highest dry matter (93.98 ± 0.54 %), protein (8.62 % fresh weight) and energy (402.9 ± 1.3 kcal 100 g^{-1}); Jaseh had the highest vitamin A (82,308 ± 13,446 µg RAE 100 g^{-1}) — exceeding orange-fleshed sweet potato (5,000–23,000 µg 100 g^{-1}; Arutselvan et al., 2023) — and total phenolics (19.82 ± 0.69 mg 100 g^{-1}), while Mwende was richest in flavonoids and folate. Vitamin C was uniformly exceptional across cultivars (1,716–2,412 mg 100 g^{-1}; n.s., $p = 0.205$). Relative to *D. rotundata* (Alinnor & Akalezi, 2010), all three Kumbu cultivars supply more than double the metabolisable energy on a dry-weight basis, together with higher protein, fat and ash (Table 2). Anti-nutrient levels (tannins 3.6–4.1 mg 100 g^{-1}; oxalates 394–410 mg 100 g^{-1}; phytates ≈ 0.0002 mg 100 g^{-1}) remained well below thresholds of dietary concern (oxalate ceiling 2–5 g day^{-1}; Hassan & Umar, 2004), so Kumbu can be regarded as safe for regular consumption.

Table 2: Comparative nutritional profile of Kumbu cultivars and the reference staple *D. rotundata*.

Parameter	Kumbu (Nyake)	Kumbu (Jaseh)	*D. rotundata**
Energy (kcal 100 g^{-1}, dry basis)	402.9 ± 1.3	397.7 ± 0.6	~175 (fresh)
Protein (% fresh weight)	8.62	–	2.7
Vitamin C (mg 100 g^{-1})	1,716–2,412 (all cultivars)	—	n/a
Vitamin A (µg RAE 100 g^{-1})	11,645 ± 3,058	82,308 ± 13,446	n/a

* *D. rotundata* reference values from Alinnor & Akalezi (2010).

Taken together, the survey, characterisation, agronomic and nutritional results converge on a single narrative: Kumbu is a taxonomically distinct, agronomically responsive and nutritionally superior indigenous yam complex whose survival is nevertheless threatened by seed scarcity and eroding cultural transmission — a combination that positions it as an urgent candidate for participatory domestication rather than passive conservation.

Conclusions and Outlook

This study provides the first integrated ethnobotanical, morpho-molecular, agronomic and nutritional evidence base for Kumbu yam. It comprises three genetically and morphologically distinct candidate *Dioscorea* species (Nyake, Mwende, Jaseh) closely allied to the wild African yams *D. praehensilis* and *D. abyssinica*, with a high probability of representing taxa new to science, yet it is simultaneously "in the process of domestication" and "in the process of extinction" as cultivation and cultivar knowledge decline. Sett propagation with poultry manure and beneficial-microbe inoculation quadruples yield relative to minisett while lowering anti-nutrient content, and Kumbu's nutrient density — more than double the metabolisable energy of *D. rotundata*, exceptional vitamin C, and safe anti-nutrient levels — positions it as a genuine climate-smart "super staple." We recommend coordinated conservation and domestication, formal taxonomic description and germplasm registration, extension-led scaling of the sett–manure–microbial package, and integration of Kumbu into national dietary-diversification and biofortification strategies.

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